Agenda Item E.8
Attachment 11
September 2017

Status of California Scorpionfish (*Scorpaena guttata*) Off Southern California in 2017

Melissa H. Monk[1]
Xi He[1]
John Budrick[2]

[1]Southwest Fisheries Science Center, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, 110 Shaffer Road, Santa Cruz, California 95060

[2]California Department of Fish and Wildlife, 350 Harbor Blvd., Belmont, California 94002

This report may be cited as:

Monk, M. H. ,He, X., and Budrick, J. 2017. Status of the California Scorpionfish (*Scorpaena guttata*) Off Southern California in 2017.. Pacific Fishery Management Council, Portland, OR. Available from http://www.pcouncil.org/groundfish/stock-assessments/

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Executive Summary

Stock

This assessment reports the status of the California scorpionfish (*Scorpaena guttata*) resource in U.S. waters off the coast of southern California (south of Pt. Conception) using data through 2016. California scorpionfish are most abundant in the southern California Bight and their range extends to Punta Eugena, Mexico, about halfway down the Baja peninsula. Catches from Mexico were not included in this assessment, and catches from Mexican waters that were landed in the U.S. were excluded from the catch histories.

Catches

Information on historical landings of California scorpionfish are available back to 1916, with the assumption that from 1916 to 1968 all of the commercial landings were caught by hook-and-line (Table a). Commercial landings were small during the years of World War II, ranging between 16 to 63 metric tons (mt) per year. The recreational fleets began ramping up in the 1960s and have dominated the catch since then (Figures a-b). The party/charter fleet has been the major component of the recreational sector since the early 2000s.

The catches from the commercial fleets has been small in the last decade, range from 1.19 to 4.54 mt per year (Figure c). Since 2000, annual total landings of California scorpionfish have ranged between 57-199 mt, with landings in 2016 totaling 74 mt.

California scorpionfish is not a major component of the commercial or recreational fisheries in southern California. There has been little discarding of the species in the commercial fisheries and the discard mortality rate for the recreational fisheries is estimated to be 7%. The peak in discards from 2001-2005 was due to the closure of California scorpionfish fishery between two and ten months of the year during that period.

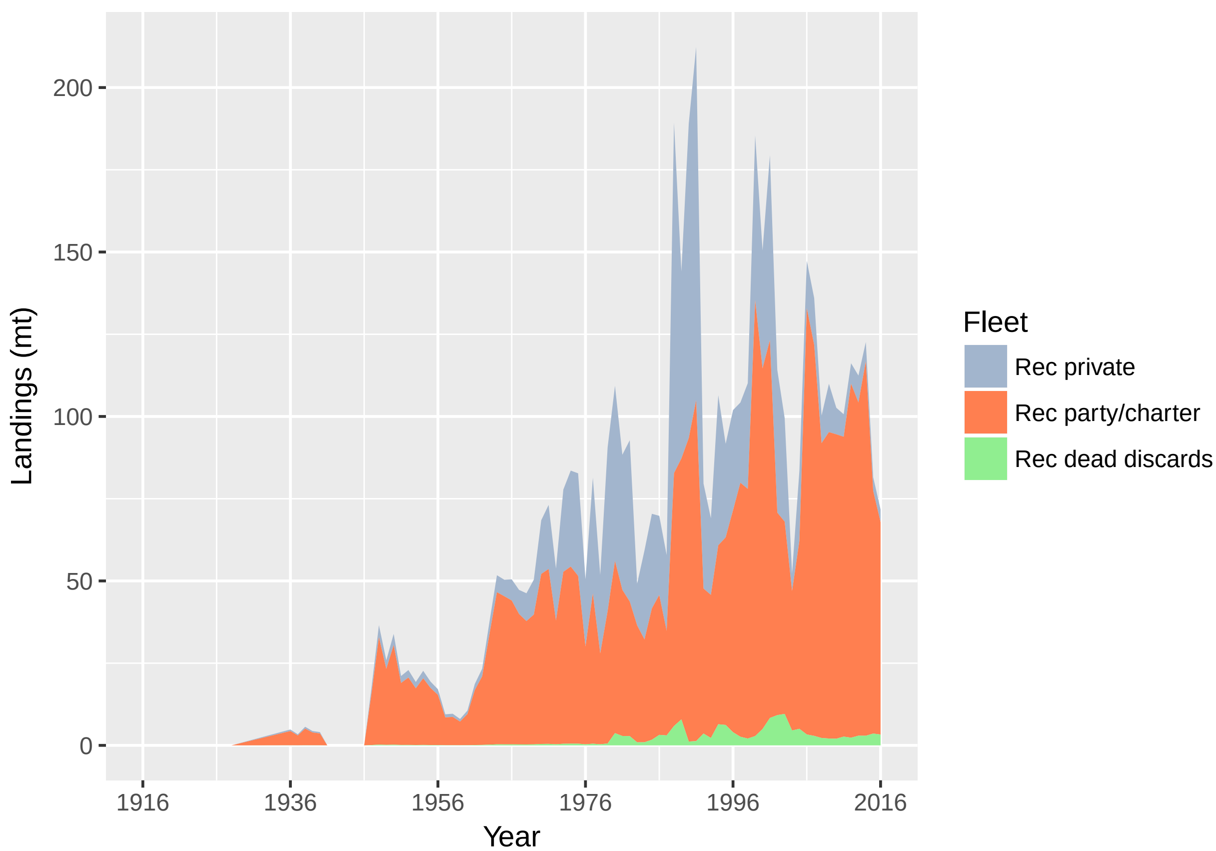

Figure a: California scorpionfish catch history for the recreational fleets.

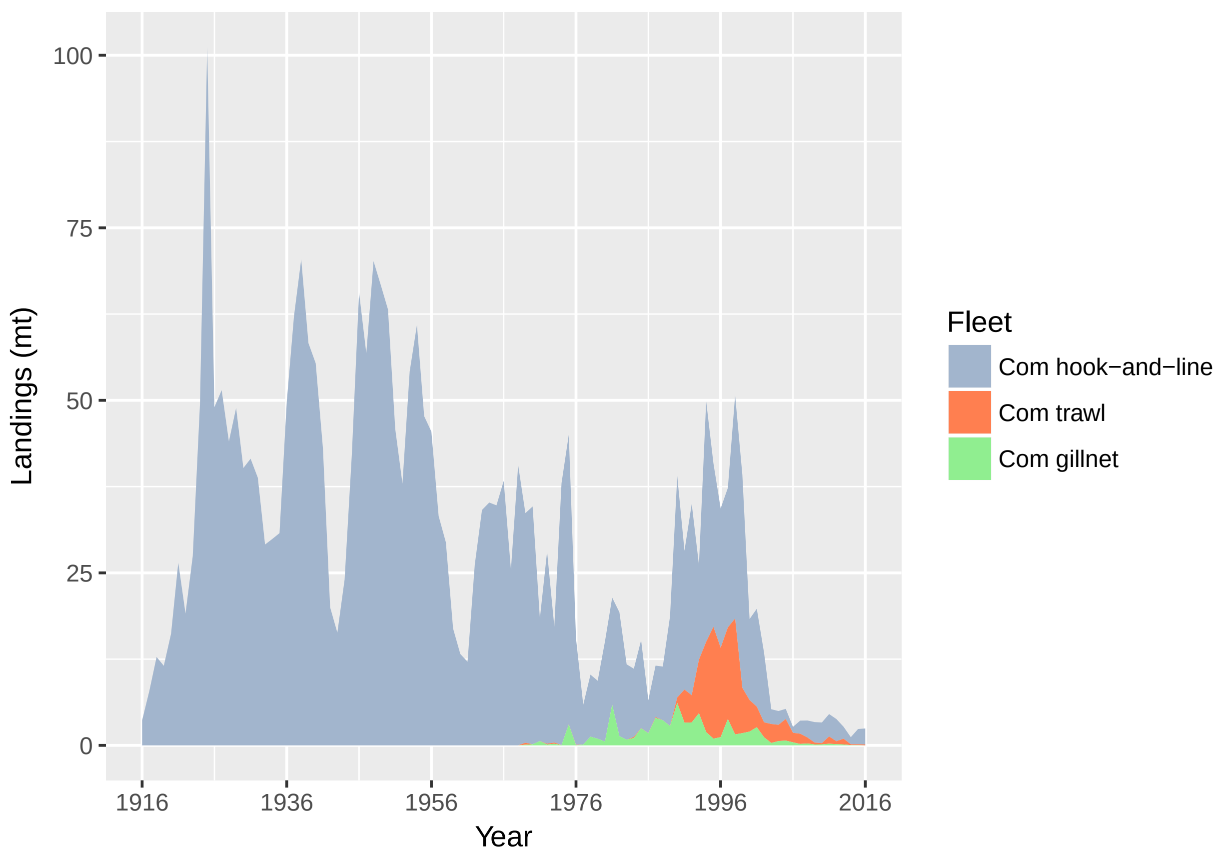

Figure b: Stacked line plot of California scorpionfish catch history for the commercial fleets.

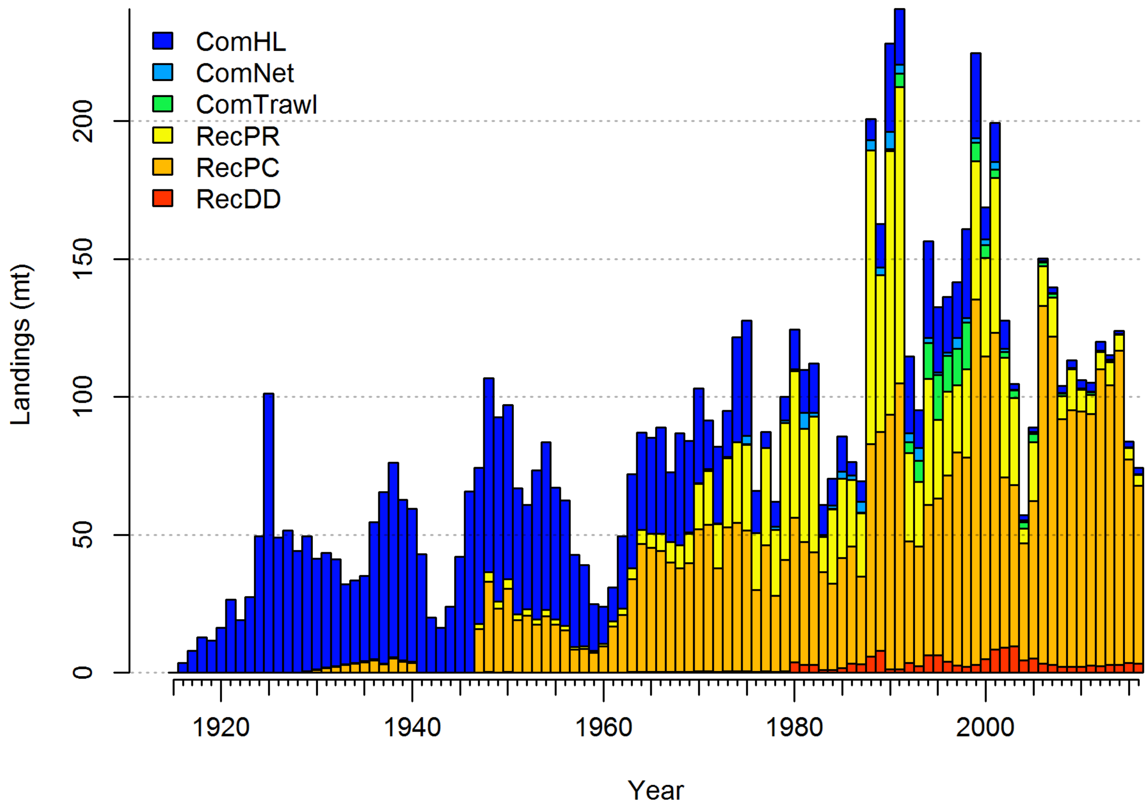

Figure c: Catch history of California scorpionfish in the base model.

Table a: Recent California scorpionfish landings (mt) by recreational (Rec.) and commercial (Com.) fleets.

Year	Rec. Private	Rec. Party/Charter	Rec. Dead Discards	Com. Hook-and-line	Com. Trawl	Com. Gillnet	Total
2007	14.24	118.87	2.89	1.90	1.48	0.21	139.58
2008	8.38	89.65	2.25	2.46	0.86	0.28	103.89
2009	14.68	93.16	2.09	2.97	0.27	0.13	113.31
2010	8.07	92.55	2.03	2.99	0.18	0.14	105.97
2011	6.84	91.18	2.66	3.24	1.05	0.24	105.21
2012	6.22	107.63	2.34	3.22	0.43	0.18	120.00
2013	8.18	101.31	2.94	1.73	0.83	0.14	115.14
2014	5.88	113.83	2.93	1.03	0.13	0.04	123.82
2015	4.15	73.78	3.59	2.21	0.13	0.03	83.89
2016	3.86	64.56	3.29	2.32	0.13	0.00	74.16

Data and Assessment

This a new full assessment for California scorpionfish, which was last assessed in 2005 (Maunder et al. 2005) using Stock Synthesis II version 1.18. This assessment uses the newest version of Stock Synthesis (3.30.05). The model begins in 1916, and assumes the stock was at an unfished equilibrium that year. In this assessment, aspects of the model including landings, data, and modelling assumptions were re-evaluated. The assessment was conducted using the length- and age-structured modeling software Stock Synthesis (version 3.30.05.03). The population was modeled allowing separate growth and mortality parameters for each sex (a two-sex model) from 1916 to 2016, and forecast beyond 2016.

All of the data sources for California scorpionfish have been re-evaluated for 2016, including the historical fishery catch-per-unit effort time-series. The landings history has been updated and extended back to 1916. Harvest was negligible prior to that year. Survey data from five sources were used to develop indices of abundance: 1) Publicly Owned Treatment Works (POTW) trawl surveys, 2) the NWFSC trawl survey, 3) a fishery-independent gill net survey, 4) the Southern California Bight regional monitoring program trawl survey, and 5) the onboard observer survey for retained catch. Length and conditional age-at-length compositions were also created for each fishery-dependent and -independent data source, including a nuclear power generating station impingement survey that did not have an associated index of abundance.

The definition of fishing fleets hs changed from those in the 2005 assessment.
Six fishing fleets were specified within this model: 1) a combined commercial hook-and-line, fish pot, and "other gear" fleet, 2) the commercial gill net fleet, 3) the commercial trawl fleet, 4) the recreational party/charter boat fleet (retained catch only), 5) the recreational private boat fleet (retained catch only), and 6) a discard fleet that combined the estimated discards from the recreational party/charter and private boat fleets.

The assessment uses landings data; catch-per-unit-effort and survey indices; length or age composition data for each year and fishery or survey (with conditional age-at-length composition data for the NWFSC trawl survey); information on weight-at-length; and estimates of ageing error. Recruitment at "equilibrium spawning output", length-based selectivity of the fisheries and surveys, retention of the fishery, catchability of the surveys, growth, the time-series of spawning biomass, age and size structure, and current and projected future stock status are outputs of the model. Natural mortality and steepness were fixed in the final model. This was done due to relatively flat likelihood surfaces, such that fixing parameters and then varying them in sensitivity analyses was deemed the best way to characterize uncertainty.

Although there are many types of data available for California scorpionfish since the 1980s which were used in this assessment, there is little information about steepness and natural mortality. Estimates of steepness are uncertain partly because of highly variable recruitment. Uncertainty in natural mortality is common in many fish stock assessments even when length and age data are available.

A number of sources of uncertainty are now addressed in this assessment. This assessment includes gender differences in growth, an updated length-weight curve, and new conditional length at age data. One of the largest sources of uncertainty that is not considered in the current model is the proportion of the stock in Mexico and the connectivity between the portion of the fishery in Mexican and U.S. waters.

A base model was selected which best captures the central tendency for those sources of uncertainty considered in the model for the California scorpionfish stock in southern California (Figure d).

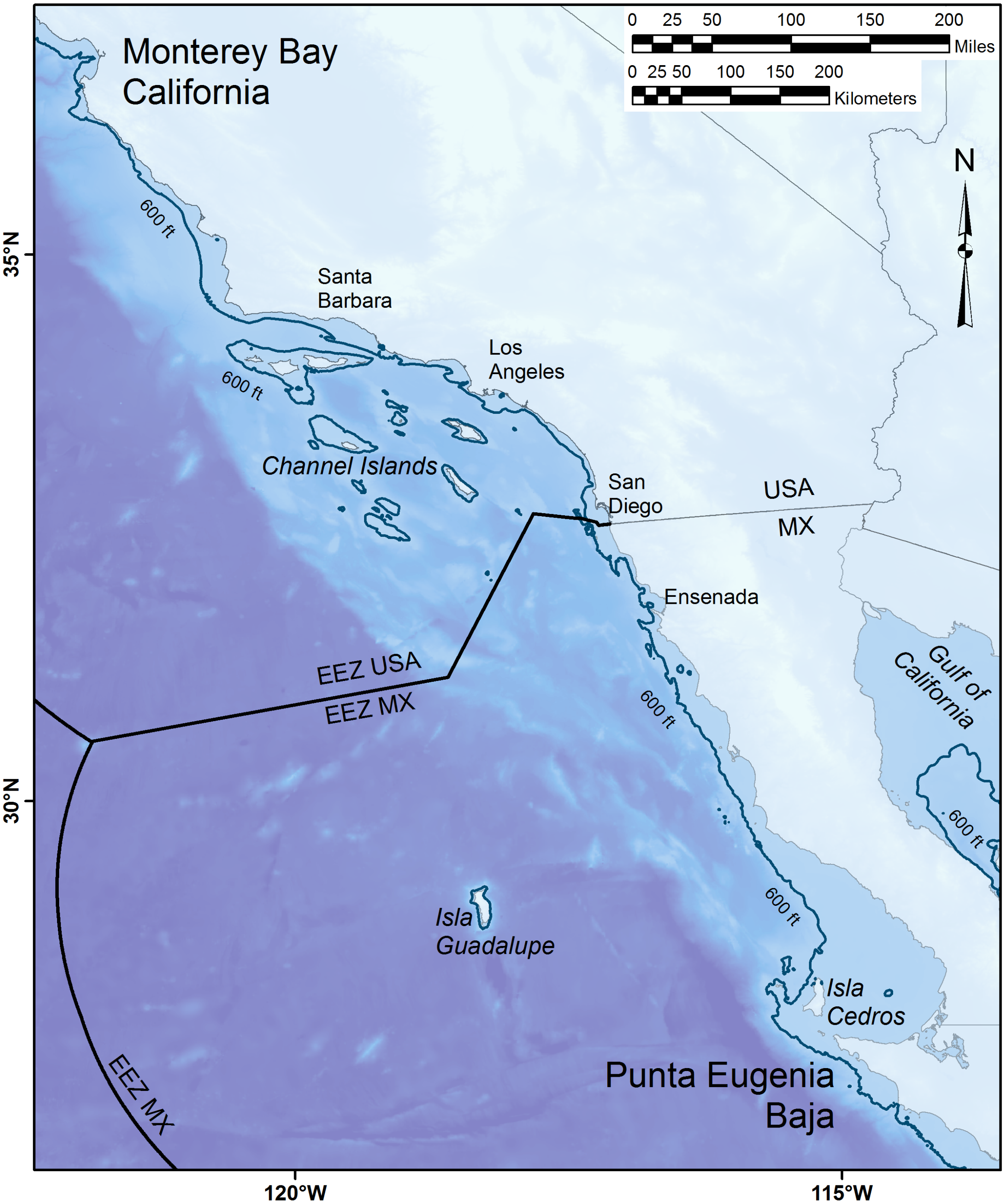

Figure d: Map depicting the distribution of California scorpionfish out to 600 ft. The stock assessment is bounded at Pt. Conception in the north to the U.S./Mexico border in the south.

Stock Biomass

The predicted spawning biomass from the base model generally showed a slight decline prior to 1965, when information on recruitment variability became available (Figure e and Table b). A short, but sharp decline occurred between 1965 and 1985, followed by a period cyclical variation in spawning biomass, and then a decline from 2000 to 2015. The stock showed increases in stock size in 2015 due to a combination of strong recruitment and smaller catches in 2015 and 2016. The 2016 estimated spawning biomass relative to unfished equilibrium spawning biomass is above the target of 40% of unfished spawning biomass at 54.3% (95% asymptotic interval: ± 43%-65.7%) (Figure f). Approximate confidence intervals based on the asymptotic variance estimates show that the uncertainty in the estimated spawning biomass is high.

Table b: Recent trend in beginning of the year spawning biomass and depletion for the base model for California scorpionfish.

Year	Spawning biomass (mt)	95% confidence interval	Estimated depletion	95% confidence interval
2008	1144.500	(654.46-1634.54)	0.705	(0.573-0.836)
2009	1090.480	(629.78-1551.18)	0.671	(0.55-0.793)
2010	1029.330	(597.2-1461.46)	0.634	(0.521-0.746)
2011	980.130	(571.79-1388.47)	0.603	(0.5-0.707)
2012	943.555	(553.81-1333.3)	0.581	(0.485-0.677)
2013	890.084	(518.85-1261.32)	0.548	(0.456-0.64)
2014	810.223	(462.86-1157.59)	0.499	(0.41-0.587)
2015	746.227	(412.08-1080.38)	0.459	(0.371-0.548)
2016	774.813	(426.28-1123.35)	0.477	(0.381-0.572)
2017	882.457	(484.21-1280.71)	0.543	(0.43-0.657)

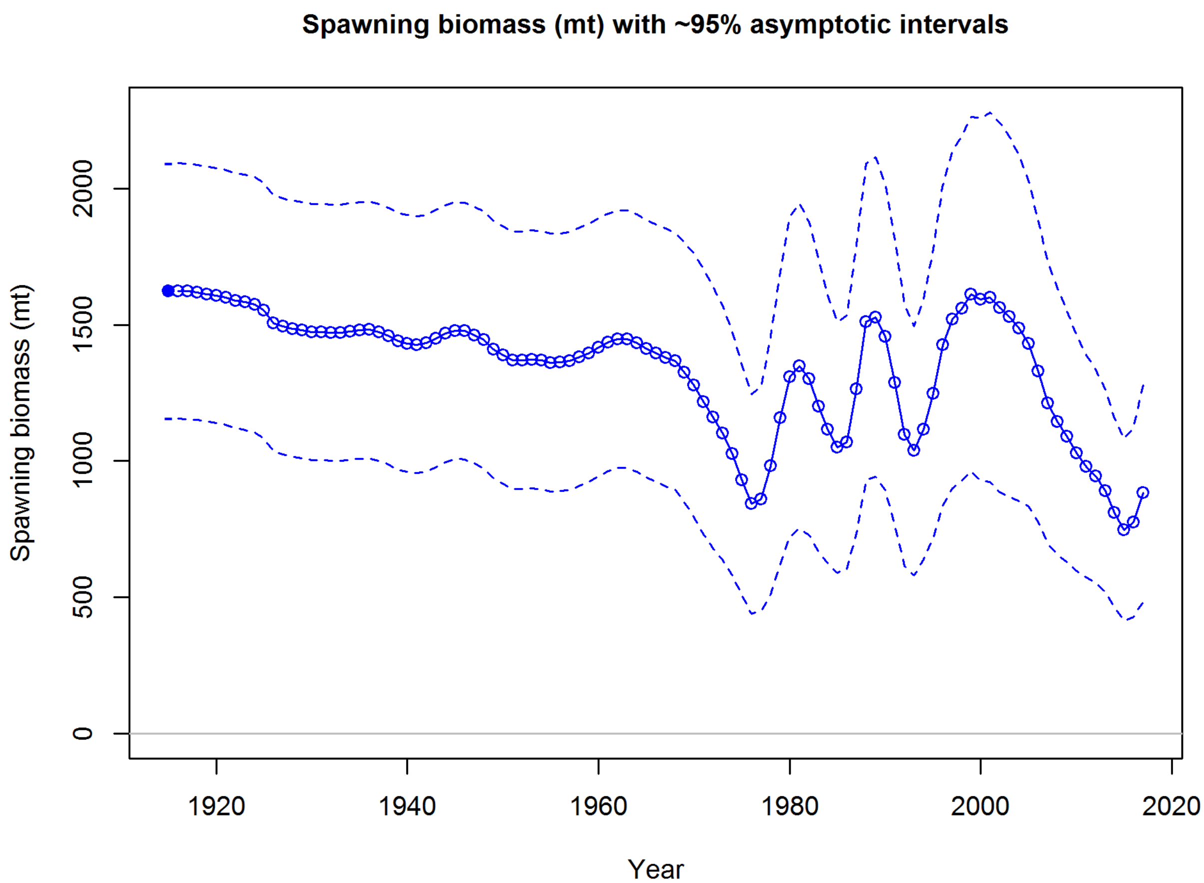

Figure e: Time series of spawning biomass trajectory (circles and line: median; light broken lines: 95% credibility intervals) for the base case assessment model.

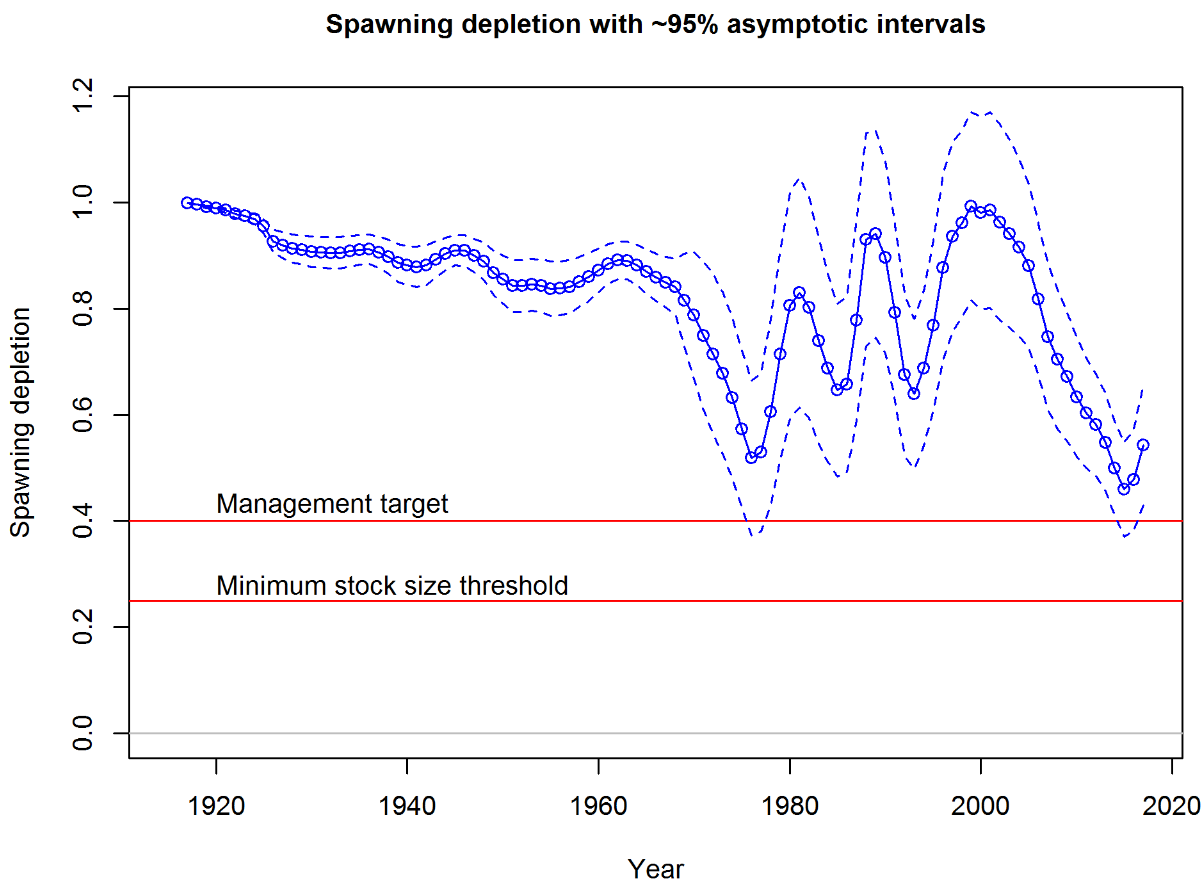

Figure f: Estimated relative depletion with approximate 95% asymptotic confidnce intervals (dashed lines) for the base case assessment model.

Recruitment

Recruitment deviations were estimated from 1965-2016 (Figure g and Table c). Historically, there are estimates of large recruitment from 1975-1977, 1984-1985 and in 1993 and 1996. There is early evidence of a strong recruitment in 2013. The four lowest recruitment estimated within the model (in ascending order) occurred in 2012, 2011, 1989, and 1988.

Table c: Recent recruitment for the base model.

Year	Estimated Recruitment (1,000s)	95% confidence interval
2008	2288.15	(1198.27 - 4369.33)
2009	2589.07	(1388.65 - 4827.18)
2010	2483.75	(1330.55 - 4636.43)
2011	1178.81	(541.36 - 2566.83)
2012	1112.10	(509.72 - 2426.35)
2013	3747.47	(2048.29 - 6856.23)
2014	3529.05	(1626.81 - 7655.6)
2015	7585.54	(3389.96 - 16973.8)
2016	3268.02	(1063.03 - 10046.74)
2017	3343.81	(1088.44 - 10272.52)

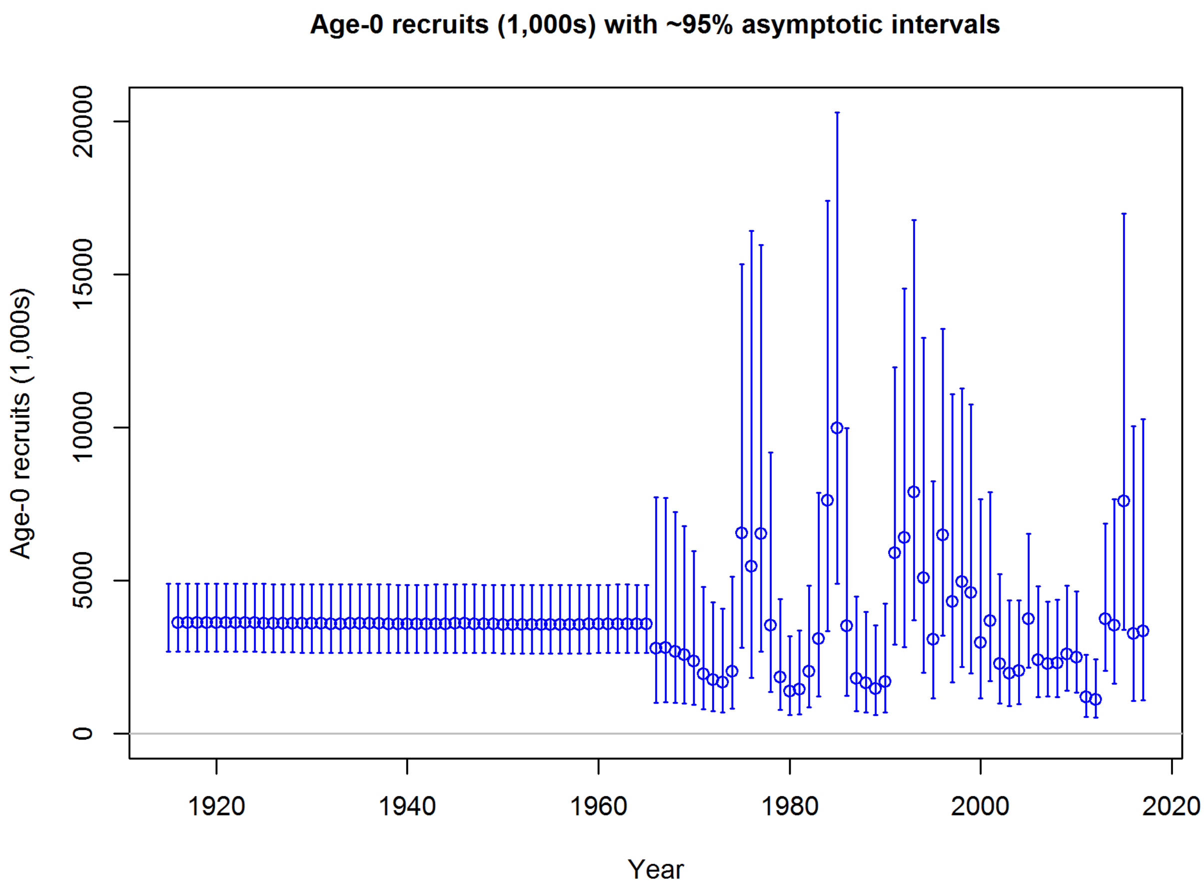

Figure g: Time series of estimated California scorpionfish recruitments for the base-case model with 95% confidence or credibility intervals.

Exploitation status

Harvest rates estimated by the base model have never exceeded management target levels (Table d and Figure h). Recent harvest rates have been relatively constant for the last decade. The estimated relative depletion is currently greater than the 40% unfished spawning output target. Recent exploitation rates on California scorpionfish were predicted to be significantly below target levels.

Table d: Recent trend in spawning potential ratio and exploitation for California scorpionfish in the base model. Fishing intensity is (1-SPR) divided by 50% (the SPR target) and exploitation is F divided by F_{SPR}.

Year	Fishing intensity	95% confidence interval	Exploitation rate	95% confidence interval
2007	0.50	(0.33-0.66)	0.06	(0.04-0.08)
2008	0.43	(0.27-0.58)	0.05	(0.03-0.07)
2009	0.47	(0.31-0.63)	0.06	(0.03-0.08)
2010	0.47	(0.31-0.63)	0.05	(0.03-0.08)
2011	0.49	(0.32-0.65)	0.06	(0.03-0.08)
2012	0.55	(0.38-0.73)	0.07	(0.04-0.09)
2013	0.56	(0.38-0.74)	0.07	(0.04-0.1)
2014	0.61	(0.43-0.8)	0.08	(0.05-0.11)
2015	0.50	(0.33-0.67)	0.05	(0.03-0.08)
2016	0.47	(0.3-0.64)	0.04	(0.02-0.06)

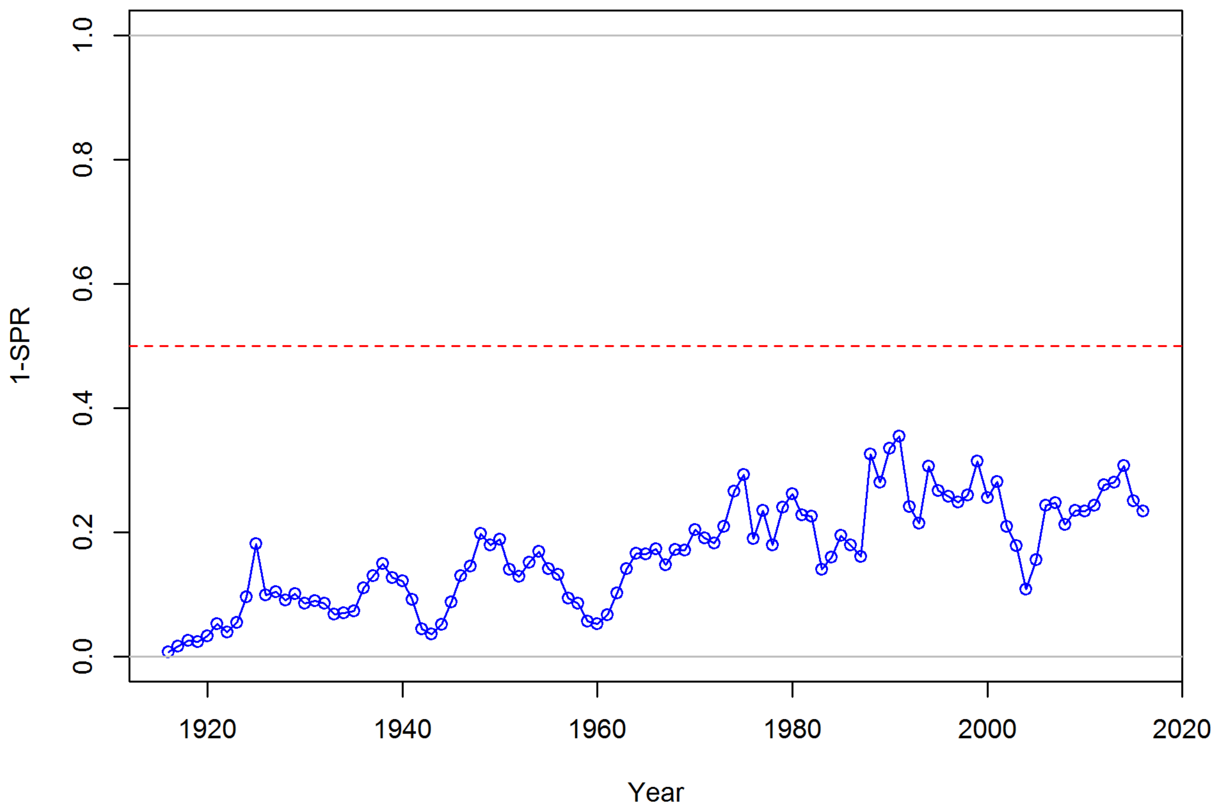

Figure h: Estimated spawning potential ratio (SPR) for the base-case model. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as a red horizontal line and values above this reflect harvests in excess of the overfishing proxy based on the $SPR_{50\%}$ harvest rate. The last year in the time series is 2016.

Ecosystem Considerations

In this assessment, ecosystem considerations were not explicitly included in the analysis. This is primarily due to a lack of relevant data and results of analyses (conducted elsewhere) that could contribute ecosystem-related quantitative information for the assessment.

Reference Points

This stock assessment estimates that California scorpionfish in the base model is above the biomass target($SB_{40\%}$), and well above the minimum stock size threshold ($SB_{40\%}$). The estimated relative depletion level for the base model in 2017 is 54.3% (95% asymptotic interval: ± 43%-65.7%, corresponding to an unfished spawning biomass of 882.457 mt (95% asymptotic interval: 484.21-1280.71 mt) of spawning biomass in the base model (Table e). Unfished age 1+ biomass was estimated to be 2921.9 mt in the base case model. The target spawning biomass ($SB_{40\%}$) is 649.8 mt, which corresponds with an equilibrium yield of 247.2 mt. Equilibrium yield at the proxy F_{MSY} harvest rate corresponding to $SPR_{50\%}$ is 232.4 mt (Figure i).

Table e: Summary of reference points and management quantities for the base case base model.

Quantity	Estimate	~95% Confidence Interval
Unfished spawning biomass (mt)	1624.4	(1156.4-2092.5)
Unfished age 1+ biomass (mt)	2921.9	(2052.8-3791.1)
Unfished recruitment (R_0)	3619.8	(2518.6-4721)
Spawning biomass (2017, mt)	882.5	(484.2-1280.7)
Depletion (2017)	0.5432	(0.4299-0.6565)
Reference points based on $\mathbf{SB_{40\%}}$		
Proxy spawning biomass ($B_{40\%}$)	649.8	(462.5-837)
SPR resulting in $B_{40\%}$ ($SPR_{B40\%}$)	0.4589	(0.4589-0.4589)
Exploitation rate resulting in $B_{40\%}$	0.1741	(0.1601-0.1882)
Yield with $SPR_{B40\%}$ at $B_{40\%}$ (mt)	247.2	(168.6-325.9)
Reference points based on SPR proxy for MSY		
Spawning biomass	723.8	(515.2-932.3)
SPR_{proxy}	0.5	
Exploitation rate corresponding to SPR_{proxy}	0.1502	(0.1383-0.1621)
Yield with SPR_{proxy} at SB_{SPR} (mt)	232.4	(158.5-306.4)
Reference points based on estimated MSY values		
Spawning biomass at MSY (SB_{MSY})	358.8	(250.6-467)
SPR_{MSY}	0.2974	(0.2857-0.3091)
Exploitation rate at MSY	0.3236	(0.2917-0.3554)
MSY (mt)	281.3	(192.2-370.4)

Management Performance

California scorpionfish has been managed as a single-species outside of a complex since 2003. The estimated catch of California scorpionfish north below the ACL in all years (2007-2017) except for in 2014 when the catch exceeded the ACL (and ABC) by 6.8 mt. A summary of these values as well as other base case summary results can be found in Table f.

Unresolved Problems and Major Uncertainties

As in most/all stock assessments, the appropriate value for stock-recruit steepness remains a major uncertainty for California scorpionfish. In this assessment a prior value from a meta-analysis of West Coast rockfish was used.

Assessment results for the base model are sensitive to natural mortality. When the natural mortality parameter is estimated by the model, the result is a value of female natural mortality that is higher than the STAT believed is biologically plausible. At the high value of female

Table f: Recent trend in total catch (mt) relative to the harvest specifications. Estimated total catch reflect the commercial and recreational removals. The OFL was termed the ABC prior to implementation of the FMP Amendment 23 in 2011. Likewise, the ACL was termed OY prior to 2011 and the ABC was redefined to reflect the uncertainty in estimating the OFL.

Year	OFL (mt; ABC prior to 2011)	ABC (mt)	ACL (mt; OY prior to 2011)	ACT	Estimated total catch (mt)
2007	219		175		139.583
2008	219		175		103.887
2009	175		175		113.318
2010	155		155		105.968
2011	141	135	135		105.215
2012	132	126	126		120.008
2013	126	120	120		115.142
2014	122	117	117		123.822
2015	119	114	114		83.8908
2016	117	111	111		74.1613
2017	289	264	150	110	-
2018	278	254	150	110	-

natural mortality also produced a stock with an estimated lnR_0 an order of magnitude higher than when natural mortality was fixed at the prior. Additional analyses and studies should be conducted to determine an appropriate prior distribution for California scorpionfish.

The time series of recruitment deviations is driving the trend in abundance in the base model. Initial explorations of mapping the estimated recruitment deviations to the CalCOFI sea surface temperature indicated correlations may be present. Additional research should be conducted to explore the environmental drivers releated to California scorpionfish recruitment.

The NMFS shelf-slope survey was the only available source of otoliths for California scorpionfish.
It it unknown if the age and length distribution of the California scorpionfish deeper than 55 m (survey area) is the similar to that in waters shallower than 55 m. The majority of California scorpionfish aged were males, and it is unknown if that was driven by the depth distribution, time of sampling, or other factors.

The current term of reference for stock assessment require development of a single decision table with states of nature ranging along the dominant axis of uncertainty. This presumes that uncertainty is consequential only for a single variable or estimated quantity, such as natural mortality, steepness, or ending biomass. This approach may fail to capture important elements of uncertainty that should be communicated to the Council and its advisory bodies. Additional flexibility in the development of decision tables is needed.

Decision Table

The forecasts of stock abundance and yield were developed using the final base model, with the forecasted projections of the OFL presented in Table g. The total catches in 2017 and 2018 are set to the PFMC adopted California scorpionfish ACL of 150 mt.

Uncertainty in the forecasts is based upon the three states of nature agreed upon at the STAR panel and are based on a low value of M, 0.164, the base model value of M, 0.235, and a high value, 0.2745. The total catches in 2017 and 2018 are set to the average annual catch from 2015-2016 (79.03) and not the ABC or OFL due recent trends in total catch being significantly lower than the OFL and ABC. The average of 2015-2016 catch by fleet was used to distribute catches in forecasted years. Current medium-term forecasts based on the alternative states of nature project that the stock, under the current control rule as applied to the base model, will decline towards the target stock size Table h. The current control rule under the low state of nature results in a stock decline into the precautionary zone, while the high state of nature maintains the stock at nearer unfished levels. Removing the high M catches under the base model M and high M states of nature results in the population going remaining at a level of spawning biomass during the projection period, and higher initial values of lnR_0.

Table g: Projections of potential OFL (mt) using the base model forecast and assuming a total catch of 150 mt in 2017 and 2018. The control rule target is set to 0.956.

Year	OFL
2017	274.71
2018	297.86
2019	336.59
2020	331.08
2021	314.81
2022	297.65
2023	283.48
2024	272.66
2025	264.54
2026	258.43
2027	253.80
2028	250.27

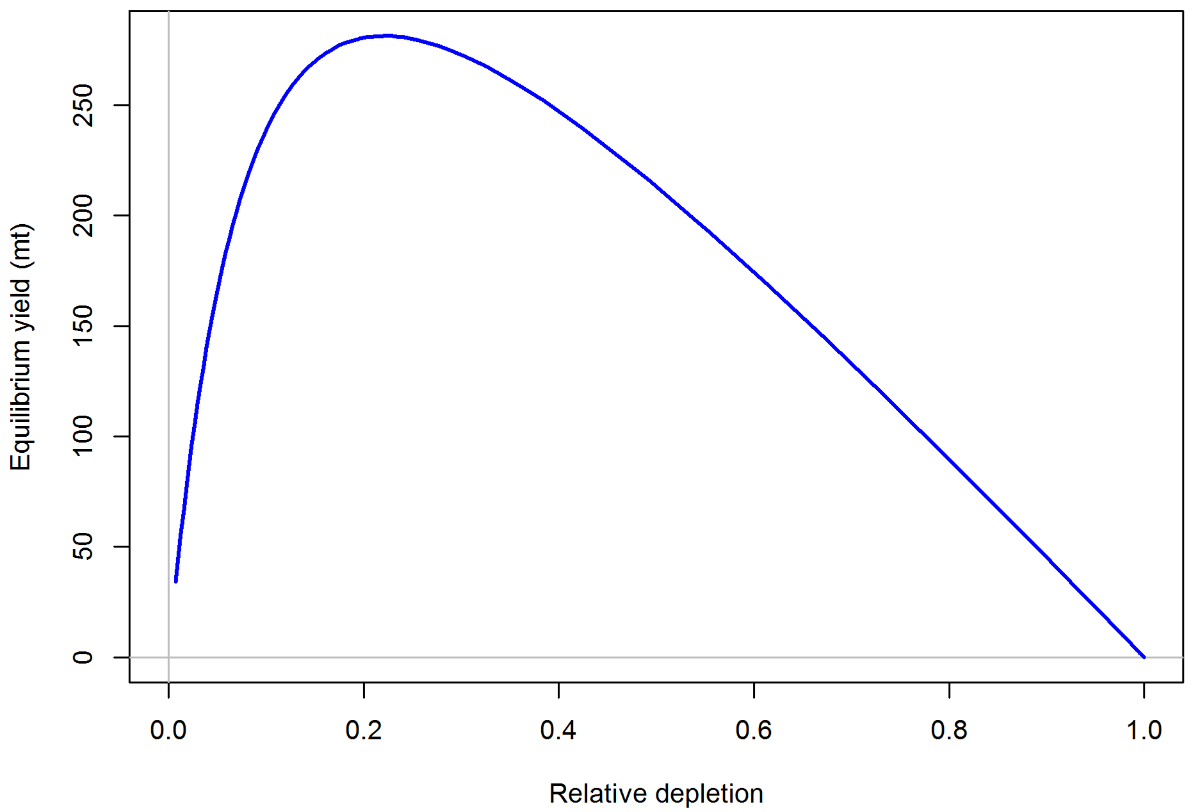

Figure i: Equilibrium yield curve for the base case model. Values are based on the 2016 fishery selectivity and with steepness fixed at 0.718.

Table h: Summary of 10-year projections beginning in 2018 for alternate states of nature based on an axis of uncertainty for the base model. Columns range over low, mid, and high states of nature, and rows range over different assumptions of catch levels. An entry of "–" indicates that the stock is driven to very low abundance under the particular scenario.

			States of nature					
			Low M 0.164		Base M 0.235		High M 0.2745	
	Year	Catch	Spawning biomass	Depletion	Spawning biomass	Depletion	Spawning biomass	Depletion
Constant Catch	2019	150.00	587.05	0.47	1154.73	0.71	2252.89	0.84
	2020	150.00	584.87	0.47	1174.89	0.72	2312.02	0.86
	2021	150.00	574.64	0.46	1176.29	0.72	2331.33	0.87
	2022	150.00	561.72	0.45	1169.09	0.72	2330.83	0.87
	2023	150.00	548.66	0.44	1158.79	0.71	2321.64	0.86
	2024	150.00	536.43	0.43	1148.13	0.71	2309.70	0.86
	2025	150.00	525.20	0.42	1138.24	0.70	2297.82	0.86
	2026	150.00	514.89	0.41	1129.45	0.70	2287.10	0.85
	2027	150.00	505.35	0.40	1121.77	0.69	2277.85	0.85
	2028	150.00	496.46	0.40	1115.12	0.69	2270.05	0.85
Estimated MSY	2019	232.40	573.15	0.46	984.92	0.61	1779.53	0.66
	2020	232.40	588.87	0.47	955.43	0.59	1673.88	0.62
	2021	232.40	592.42	0.47	912.16	0.56	1560.33	0.58
	2022	232.40	588.94	0.47	869.23	0.54	1462.95	0.54
	2023	232.40	584.63	0.47	837.51	0.52	1400.62	0.52
	2024	232.40	579.50	0.46	812.51	0.50	1353.76	0.50
	2025	232.40	575.83	0.46	796.20	0.49	1327.05	0.49
	2026	232.40	572.04	0.46	782.22	0.48	1302.32	0.48
	2027	232.40	569.72	0.45	773.77	0.48	1290.11	0.48
	2028	232.40	567.04	0.45	765.22	0.47	1275.09	0.47
ACL = ABC	2019	346.30	587.05	0.47	1154.73	0.71	2252.89	0.84
	2020	333.89	479.44	0.38	1068.32	0.66	2206.66	0.82
	2021	313.01	383.32	0.31	983.88	0.61	2142.68	0.80
	2022	293.00	311.34	0.25	917.22	0.56	2085.85	0.78
	2023	277.18	260.27	0.21	869.36	0.54	2042.74	0.76
	2024	265.38	221.15	0.18	835.93	0.51	2012.49	0.75
	2025	256.64	187.64	0.15	812.37	0.50	1992.23	0.74
	2026	250.12	157.42	0.13	795.36	0.49	1979.19	0.74
	2027	245.19	129.79	0.10	782.82	0.48	1971.20	0.73
	2028	241.44	104.22	0.08	773.46	0.48	1966.69	0.73

Table i: Base case results summary.

Quantity	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Landings (mt)										
Total Est. Catch (mt)										
OFL (mt)										
ACL (mt)										
(1-SPR)(1-$SPR_{50\%}$)	0.43	0.47	0.47	0.49	0.55	0.56	0.61	0.50	0.47	
Exploitation rate	0.05	0.06	0.05	0.06	0.07	0.07	0.08	0.05	0.04	
Age 1+ biomass (mt)	2306.33	2156.96	2047.95	1948.44	1869.84	1768.52	1630.70	1556.37	1534.81	1713.25
Spawning biomass	1144.5	1090.5	1029.3	980.1	943.6	890.1	810.2	746.2	774.8	882.5
95% CI	(654.46-1634.54)	(629.78-1551.18)	(597.2-1461.46)	(571.79-1388.47)	(553.81-1333.3)	(518.85-1261.32)	(462.86-1157.59)	(412.08-1080.38)	(426.28-1123.35)	(484.21-1280.71)
Depletion	0.7	0.7	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5
95% CI	(0.573-0.836)	(0.55-0.793)	(0.521-0.746)	(0.5-0.707)	(0.485-0.677)	(0.456-0.64)	(0.41-0.587)	(0.371-0.548)	(0.381-0.572)	(0.43-0.657)
Recruits	2288.15	2589.07	2483.75	1178.81	1112.10	3747.47	3529.05	7585.54	3268.02	3343.81
95% CI	(1198.27 - 4369.33)	(1388.65 - 4827.18)	(1330.55 - 4636.43)	(541.36 - 2566.83)	(509.72 - 2426.35)	(2048.29 - 6856.23)	(1626.81 - 7655.6)	(3389.96 - 16973.8)	(1063.03 - 10046.74)	(1088.44 - 10272.52)

Research and Data Needs

We recommend the following research be conducted before the next assessment:

There are a number of areas of research that could improve the stock assessment for California scorpionfish. Below are issues identified by the STAT team and the STAR panel:

1. **Natural mortality**: Both natural mortality and steepness were fixed in the base model. The natural mortality estimate used the assessment was based on maximum age. The collection of age data for older females may improve the ability to estimate female natural mortality in the model. The NWFSC trawl survey was the only available source of age data for this assessment, of which there were a number of age-1 fish and the data were dominated by males. It may also be possible to evaluate mortality by quantifying predation by major predators of scorpionfish, such as octopus.

   Tagging study to estimate natural mortality for scorpionfish should be considered. This project could be designed as a cooperative research project with the charter fleet in southern California.

2. **Steepness**: California scorpionfish has not been fished to a level where information on steepness is available. A meta-analysis for species with similar breeding strategies to California scorpionfish could be conducted if data are available. A meta-analysis of steepness should be done for species with the same reproductive strategy as scorpionfish.

3. **Stock south of the U.S. border**: No available information on the status of California scorpionfish in Mexico could be found. A number of emails were sent to researchers in Mexico and none were returned. It is known that a portion of the stock resides in Mexico and that boat leaving from San Diego target California scorpionfish off the Coronado Islands.

4. **Sex ratio**: The sex ratio in the only published work by Love et al. (1987) and samples from the NWFSC trawl survey were skewed towards males. Data on sex ratios from the recreational or commercial fisheries would help in determining the sex ratio of the population.

5. **Aggregating behavior**: Aggregative behavior in both spawning and non-spawning seasons of California scorpionfish is not well understood. Studies are needed to evaluate the environmental or ecological conditions that govern this behavior.

6. **Fecundity/maturity**: A reproductive biology study of California scorpionfish is needed.There are currently no estimates of fecundity for California scorpionfish. The hard copies of data from the only estimates of maturity for California scorpionfish by Love et al. (1987) are no longer available. Some data on the spatial distribution of the eggs are available from CalCOFI, but were not keypunched to the species level. California scorpionfish mature at a young age, and additional data can help inform the maturity ogive.

No studies have been done of the relationship between weight and reproductive output. California scorpionfish have a different reproductive strategy than rockfish, and seasonal protection of spawning areas may help maintain reproductive capacity of the stock.

7. **Discard mortality**: Many scorpionfish are discarded at sea. The assessment used estimates of discard mortality of a distantly related species (lingcod) in a different ecological setting (Karpov 1996). Studies of discard mortality are needed to parametrize the assessment model.

8. **Environmental covariates**: The relationship between environmental conditions and recruitment for scorpionfish should be further explored. Preliminary exploration using CalCOFI temperature data suggested that a relationship existed, but other time series may correlate more strongly given that scorpionfish are a near-shore species. Scorpionfish appear to be a relatively hardy and adaptable species and may expand northward in a warming climate.

9. **Stephens and MacCall filtering**: Ad hoc criteria are used to identify a threshold when applying the Stephens and MacCall method of selecting records for CPUE index development. Further research is needed to determine whether threshold selection criteria can be optimized.

10. **Discard fleet modeling**: Modeling discard as a separate fleet, as was done for California scorpionfish, is a simple and intuitive approach, but the strengths and weaknesses of this approach are unclear. This method should be compared to the more standard approach of modeling discard with retention curves to ensure the model results are not strongly affected by the method used.

11. **MCMC in Stock Synthesis**: The Markov chain Monte Carlo (MCMC) method implemented in Stock Synthesis is not reliable in many cases. Characterizing uncertainty of the final assessment model is important, and MCMC offers advantages over asymptotic approximations using the Hessian or likelihood profiles.

12. **Decision tables**: Several alternative approaches were used this year to construct decision tables and some approaches may be better than others. The stock assessment TOR should outline the various methods that can be used, and provide recommendations if possible on preferred approaches.

13. **POTW trawl surveys**: Additional biological information (sex, otoliths, depth distribution) should be collected for California scorpionfish during the Publicly Owned Treatment Works (POTWs) trawl survey and the Southern California Bight Regional Monitoring Project (SCCWRP) trawl survey.

14. **Age validation**: An age validation study is needed for California scorpionfish.

15. **CalCOFI**: CalCOFI ichthyoplankton surveys in southern California do not currently identify scorpionfish eggs to species, though it is possible to do this in southern California waters. Species-specific identification of scorpionfish eggs is recommended to develop spawning output index for use in the next stock assessment.